Analysing Sustainable Concrete by Partial Replacement of GGBS and RCA

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Abstract- The report thoroughly explores sustainable M30 concrete options by exploring the utilization of Ground Granulated Blast Furnace Slag (GGBS) and recycled demolition waste. It delves into the environmental and structural advantages of integrating GGBS as a partial substitute for Portland cement and using demolition waste as aggregate. The primary goal of the research is to reduce the environmental impact of concrete production, promote recycling efforts, and elevate the performance of concrete structures. The results of the study suggest that GGBS and demolition waste present significant ecological benefits and enhance the properties of concrete, thus establishing them as feasible alternatives for sustainable construction practices.

Index Terms- Recycled coarse aggregate(RCA), Natural coarse aggregate, ground granulated blast furnace slag (GGBS)

Introduction

The construction industry is crucial in modern society, providing essential infrastructure and buildings for daily life. However, it is also one of the largest contributors to environmental challenges, including significant waste generation and carbon dioxide (CO_2) emissions. To mitigate these impacts, the industry is increasingly turning to sustainable practices and materials. GGBS and demolition waste can be incorporated into concrete in innovative solutions.

Demolition Waste in Concrete

Buildings and infrastructure are destroyed, resulting in demolition waste, which is also known as construction and demolition (C&D) debris. Concrete, bricks, metals, wood, and glass are among the materials included. Traditionally, a large portion of this waste ends up in landfills, leading to environmental degradation and resource depletion. However, recycling demolition waste into new concrete presents an innovative and sustainable solution.

Concrete mixes can use recycled concrete aggregates (RCA) that are produced from crushed demolition waste instead of natural aggregates. This practice offers numerous environmental and economic benefits. The demand for virgin materials is reduced, natural resources are conserved, and the carbon footprint of concrete production is reduced. Additionally, it diverts significant amounts of waste from landfills, alleviating the strain on waste management systems and reducing associated environmental hazards.

The Ground Granulated Blast Furnace Slag (GGBS)

Blast furnaces produce GGBS as a byproduct of iron-making. During iron production, slag is generated and, when rapidly quenched with water, forms granules with a glassy texture. After being dried, the granules are ground into a fine powder called GGBS. The construction industry highly values this material for its cementitious properties and environmental benefits. GGBS is produced with less energy and less CO2 emissions than Portland cement. Incorporating GGBS into concrete mixes not only reduces the overall carbon footprint but also improves the durability and strength of the concrete. GGBS-blended concrete exhibits better resistance to chemical attacks, reduced permeability, and enhanced long-term performance.

Concrete with GGBS and demolition waste in synergy

By combining both materials in concrete production, the sustainability benefits can be maximized. The use of CDW recycled aggregates leads to conservation of natural resource and reduction of landfill use, while GGBS reduces CO2 emissions and enhances concrete properties

2. Literature Survey

Ganikapudi Akhil, Talluri Maheswararao 03 (March -2023)

The study involved replacing cement at varying percentages of 0% to 60% with GGBS while maintaining a constant 30% replacement rate for coarse aggregate with demolishing waste. •Workability improved with GGBS content, with maximum workability achieved with 60% replacement

- Increased compressive strength by 40%

Er. Ramanuj Jaldhari1 & Er. Bharat Nagar06 (June -2017)

The experimental investigation involved a range of tests, including flexural strength tests on beams, compressive strength tests on cubes, and the use of GGBS as a supplementary cementitious material without replacing the cement. In the experiments, recycled coarse aggregates were added to high-strength concrete mixes in varying amounts (0% to 30%) to replace the original coarse aggregates. Additionally, 5% GGBS was added to the recycled aggregate mix.

Recycled coarse aggregate from field-demolished concrete can be used to obtain the required strength and durability characteristics by adding extra components.

Jayalakshmi Sasidharan Nair 09 (September -2016)

. To produce a grade M40 concrete mix (control mix), a concrete mix design was completed. Recycled aggregates were used to create the mixes at 40%, 50%, and 60% substitution rates for natural aggregates. The fresh and mechanical characteristics, as well as the control mix, were evaluated. The results of the tests indicated that the concrete with 50% recycled aggregate substitution demonstrated sufficient strength in comparison to the control mix. "In addition, blends were created by substituting GGBS for 40%, 50%, and 60% of the cement, along with replacing 50% of the recycled aggregates." The test findings indicated that, when compared to the control mix, the concrete

that had 40% and 50% GGBS replacement for cement and 50% recycled aggregate replacement showed adequate strength.

Md Shakir Ahmed, H S Vidyadhara10 (October -2013)

The focus of this project is solely on utilizing R.C.A. Compressive strength, split tensile strength, and flexural strength were evaluated using a variety of experiments, both with and without recycled aggregates. Crushed concrete coarse aggregates were added to the concrete at percentages of 0%, 20%, 40%, 60%, 80%, and 100% in place of the natural coarse aggregates. The test revealed that when the amount of recycled aggregate increased, the following properties steadily declined: modulus of elasticity, flexural strength, split tensile strength, and compressive strength.

D. Yong P.C and Teo01 (August -2009)

This research utilized about 200 kg of recycled concrete aggregate. The results of this study show that recycled aggregates made from on-site tested concrete samples produce excellent concrete, opposite to the viewpoint held by many researchers that recycled aggregates should only be used in non-structural applications of concrete. When recovered aggregate concrete (RAC) is compressed in order its strength, was found to exceed that of ordinary concrete. Furthermore, RAC and conventional concrete displayed comparable split tensile strength, flexural strength, and wet density. By using coarse aggregate in a saturated surface dry (SSD) state, recycled aggregate concrete's low slump can be improved.

3)MATERIALS

<u>THE GENERAL PORTLAND CEMENT (GRADE 53)</u>: The cement's 53 megapascals (MPa) of compressive strength after 28 days of curing make it suitable for use in high-stress structural applications, according to the classification '53-grade'.

<u>M SAND (MANUFACTURED SAND):</u>

Hard granite stones are crushed during the production process to produce fine particles appropriate for a variety of construction applications.

<u>COARSE AGGREGATES:</u> rock, like granite, is a necessary ingredient in concrete mixtures because it gives the building material strength and longevity.

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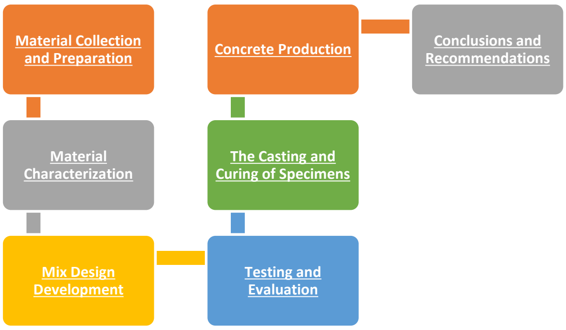
THE GRANULATED BLAST FURNACE SLAG—Ground: The production of pig iron in blast furnaces involves processing molten iron ore, and this is an byproduct of it.

DEMOLITION WASTE COARSE AGGREGATE: Recycled construction and demolition debris is the term for crushed and processed waste materials from old buildings, bridges, and infrastructure that are used in place of natural coarse aggregates in the manufacturing of concrete

4)METHODOLOGY



5)TESTS CONDUCTED

A) TESTS CONDUCTED ON MATERIALS

Table 1Summary of all basic material tests

CEMENT

SL no	Test name	values
1	Specific gravity	3.05
2	Normal consistency	28%
3	Fineness of cement	10%

FINE AGGREGATE

Sl no	Test name	Values
1	Specific gravity	2.55
2	Sieve analysis(fineness module)	4.39

NATURAL COARSE AGGREGATE

Sl no	Test name	Values
1	Specific gravity	2.69
2	Water absorption	0.25%
3	Aggregate crushing	17.55%
4	Aggregate impact	12.5%
5	Abrasion value	21.24%

RECYCLED COARSE AGGREGATE

Sl no	Test name	Values
1	Specific gravity	2.493
2	Water absorption	3.805%
3	Aggregate crushing	21.67%
4	Aggregate impact	14.9%
5	Abrasion value	25.94

GGBS

SL no	Test name	values
1	Specific gravity	2.85

MIX PROPORTION

Cement = 340 kg/m3
Water = 153 kg/m3
Small Aggregate(SSD) = 682 kg/m3
Coarse Aggregate (SSD) = 1225 kg/m3
Chemical Admixture = 3.4 kg/m3 ,
Compost-to-free water ratio = 0.45

340	**682**	**1225**
1	**2.00**	**3.60**

Table 4 compression test value

	7 DAYS	14 DAYS	28 DAYS
Conventional concrete (N/mm2)	23.89	29.25	34.25
10% GGBS +10% RCA replacement (N/mm2)	22.34	28.33	33.43
20%GGBS+20%RCA replacement(N/mm2)	21.03	27.46	31.78
30%GGBS+30%RCA replacement (N/mm2)	19.78	26.89	30.87
40%GGBS+40%RCA replacement(N/mm2)	18.78	24.32	29.76

TOTAL ALL MATERIALS USED IN THE PROJECT'S CONCRETE

Sl no	Cement (kg)	Water (ltr)	GGBS (kg)	FA (kg)	CA (kg)	RCA (kg)
1	231.05	69.76	43.45	464.7	626.76	175.5

TESTS ON FRESH CONCRETE

a)SLUMP TEST FOR CONVENTIONAL, GGBS&RCACONCRETE.

Table 2 Slump cone test

Sl no	Cement %	GGBS %	NA %	RCA %	FA %	SLUMP (mm)
1	100	0	100	0	100	97
2	90	10	90	10	100	85
3	80	20	80	20	100	84
4	70	30	70	30	100	81
5	60	40	60	40	100	87

Table 3Total Materials used in a compression test

Sl no	Cemen (kg)	%	GGBS (kg)	FA (kg)	CA (kg)	RCA (kg)
1	15.1	0	-	30.24	54.54	-
2	13.69	10	1.51	30.24	49.086	5.454
3	12.08	20	3.02	30.24	43.632	10.908
4	10.57	30	4.53	30.24	38.178	16.362
5	9.06	40	6.04	30.24	32.724	21.816
Total	117.65		15.1	181.2	218.16	54.54

b)Assessing RCA + GGBS and regular concrete's compressive strengths

Figure 1 Compressive testing

c) SPLITTING TENSILE STRENGTH CONVENTIONAL CONCRETE AND RCA+GGBS

Table 5 Total Materials used in split tensile test

	7 DAYS	14 DAYS	28 DAYS
Conventional concrete (N/mm2)	2.84	3.30	3.52
10% GGBS +10% RCA replacement (N/mm2)	2.11	2.76	3.1
20%GGBS+20%RCA replacement (N/mm2)	1.98	2.45	2.97
30%GGBS+30%RCA replacement (N/mm2)	1.76	2.20	2.60
40%GGBS+40%RCA replacement (N/mm2)	1.58	2.1	2.30

Table 6 spliting tensile strength value

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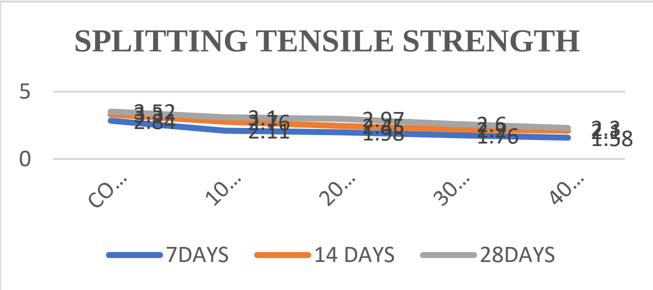
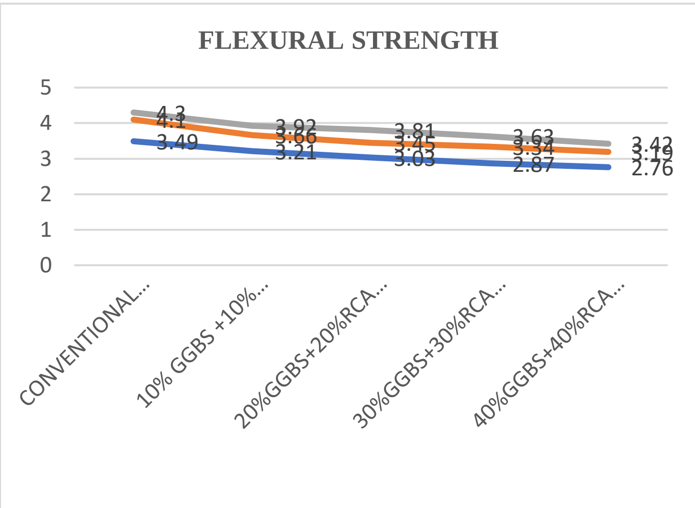
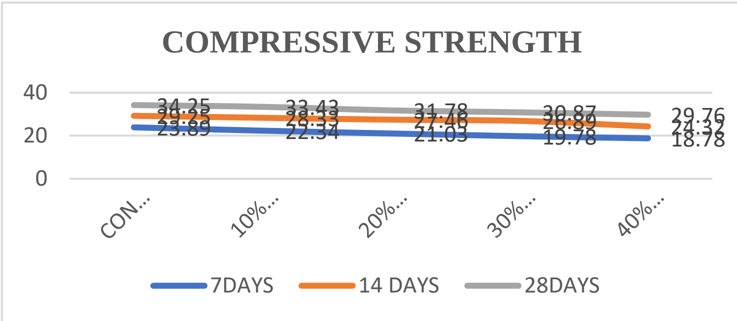
Sl no	Cement (kg)	%	GGBS (kg)	FA (kg)	CA (kg)	RCA (kg)
1	4.5	0	-	9	16.2	-
2	4.05	10	0.45	9	14.58	1.62
3	3.6	20	0.9	9	12.96	3.24
4	3.15	30	1.35	9	11.34	4.86
5	2.7	40	1.8	9	9.72	6.48
Total	18		4.5	45	64.8	16.2



	7 DAYS	14 DAYS	28 DAYS
Conventional concrete (N/mm2)	3.49	4.1	4.3
10% GGBS +10% RCA replacement (N/mm2)	3.21	3.66	3.92
20%GGBS+20%RCA replacement (N/mm2)	3.03	3.45	3.81
30%GGBS+30%RCA replacement (N/mm2)	2.87	3.34	3.63
40%GGBS+40%RCA replacement (N/mm2)	2.76	3.19	3.42



Sl no	Cement (kg)	%	GGBS (kg)	FA (kg)	CA (kg)	RCA (kg)
1	23.85	0	-	47.7	85.95	-
2	21.465	10	2.385	47.7	77.355	8.595
3	19.08	20	4.77	47.7	68.76	17.19
4	16.695	30	7.155	47.7	60.165	25.785
5	14.31	40	9.54	47.7	51.57	34.38
Total	95.4		23.85	238.5	343.8	104.76



6) Conclusion

•For M30 grade concrete GGBS is used to replace cement, and RCA is used for coarse gravel replacement by weight varying 10,20,30 and 40 per cent. The structural properties of concrete are investigated

•The compressive strength is found to decrease compared to normal concrete and the maximum decrease was obtained at 40% for 28 days. which is not allowed as per IS code.

However, the replacement can be done up to 30 % cement by GGBS & RCA as per the IS code

TheSplit tensile is found to decrease compared to normal concrete and the maximum decrease is obtained at 20% for 28 days. Which is not allowed as per the IS code

However, the replacement can be done up to 10% for tensile carrying structure

•The Flexural strength is found to decrease compared to normal concrete and the maximum decrease is obtained at 30% for 28 days. Which is not allowed as per the IS code
However, the replacement can be done up to 20% for tensile carrying structure

•Hence, GGBS&RCA replacement can done up to 30% for load-bearing bearing structure, and up to 10% replacement for tensile-carrying structure

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